Editorial

Early Warning Systems for Pandemics: Lessons Learned from Natural Hazards

A pandemic was expected. Yet, as Mami Mizutori, Head of the UNISDR, states, "past warnings of a pandemic were often ignored, despite mounting evidence…" [1]. At first glance, Early Warning Systems (EWS) developed for volcanic, earthquake, tsunami and flood hazards may seem inappropriate for diseases such as COVID-19. Unlike most environmental hazards that require organised evacuation away from a crisis point, epidemics and pandemics require people to stay put so as to cut off transmission routes. Rather than protect themselves by moving away from danger, people must protect others through their immobility. Yet, EWS are much more than simple systems that provide a siren or warning to move. For EWS to be effective they must be embedded in an extensive system of observation and communication that integrates different expert and policy cohorts, thresholds or tipping points, communication mediums and iconographies, for *the provision of timely warnings* to people with the aim of minimizing loss of life and reducing the social and economic impacts of disasters. Well-known examples are the Pacific Tsunami Early Warning Centre and the Asteroid Terrestrial-impact Last Alert System (ATLAS). EWS are intended to convey risk levels in an easy to understand format, ensure credibility and accountability, and help create transparency between different stakeholders [2]. As complex yet efficient assemblages of people, protocols and plans, EWS have been the subject of political as well as scientific experimentation since 1949, and can provide evidenced 'lessons learned' on how to translate scientific observations into alert systems as part of a pandemic response.

The rapid spread of the virus SARS-CoV-2 and associated COVID-19 disease has demonstrated that local, national, and international warning systems for pandemics are woefully underdeveloped. Five years ago the UN member states extended the definition of risk to include biological hazards, adopting the Sendai Framework for Disaster Risk Reduction, driven by countries that had experienced disease epidemics from strains of Ebola, MARS, and SARS. One of the framework's seven global targets is to substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments by 2030. Yet across recent documents - the WHO's *2019 Novel Coronavirus (2019-nCoV), Strategic Preparedness and Response Plan* (2020) [3], the Global Preparedness Monitoring Board report *A World at Risk* (2019) [4], the International Working Group on Financing Preparedness' report *From Panic and Neglect to Investing in Health Security* (2017) [5], and the International Health Regulations' *The Joint External Evaluation Tool* (2016) [6] - the term 'warning' is only mentioned twice.

Despite the Sendai Framework, only 81 countries have a national strategy for disaster risk reduction, and few of these reference pandemic threats. By contrast, throughout the 1990s and 2000s the UN held a number of EWS conferences on natural hazards resulting in a number of publications [7,8]. Following the catastrophic 2004 Indian Ocean tsunami the UN called for the development of a global EWS for all types of natural hazards for all communities. Thieren [9] argues that if an EWS were in place when the tsunami struck the Indian Ocean region, an estimated 230,000 deaths in eleven countries could have been prevented. In March 2005, the UN ISDR Platform for the Promotion of Early Warning (PPEW) undertook a global survey to identify existing capacities and gaps in EWS research, comprising of EWS conferences conducted in over 23 countries with 20 international agencies (UN ISDR PPEW, 2006) and culminating in the report *Global Survey of Early Warning Systems* [10]. The report advocated that EWS should comprise of diverse activities spanning four key elements: risk knowledge, monitoring and warning service, dissemination and communication, and response capability.

It is too late to develop a cross-border, standardised EWS for the first wave of COVID-19, but it is vital that a forensic analysis on how this crisis emerged includes an assessment of the variable successes in warning systems adopted by countries. Of particular note is the New Zealand COVID-19 Alert Level System [11]. New Zealand is relatively well prepared for natural hazards with numerous alert level systems in place for volcanoes, tsunami, and weather hazards. A similar set of protocols underpins its COVID-19 alert system. This comprises four colour-coded alert levels - prepare, reduce, restrict, and lockdown - providing clear guidance on the risk assessment, and the range of measures in place. Each alert level has specific outcomes, summaries, and measures for public health, personal movement, travel and transport, gatherings, public venues, health and disability care services, workplace, and education so that there is clarity in what can and cannot be conducted at each alert level. The guidance provided can be updated based on new scientific information, or the effectiveness of control measures (both in New Zealand, and overseas), but this new information will be subsumed into the existing EWS. New Zealand successfully transitioned to Alert Level 3 'Restrict' on Monday 27th April for a minimum of two weeks [12], and an evaluation of the cases of COVID-19 will provide insights into the success of the measures in place and the effectiveness of this system.

On 24th April, members of the Welsh government stated they wanted to implement a traffic light system following initial lockdown [13]. Red, amber, and green are commonly adopted in EWS designs for natural hazards due to their ease of understanding, but do constrain the number of levels to 3. Following this, the UK announced its COVID-19 Alert Levels on 10th May, also adopting a traffic light system; this is closely linked to the UK Terrorism Threat Levels [14]. Other countries are considering copying New Zealand's epidemic EWS, with key commentators in the USA also advocating for a warning system based on their colour-coded Homeland Security Model. Andy Slavitt, for example, the former Acting Administrator of the Centers for Medicare and Medicaid Services appointed by President Obama, argues: "We're going to need to find a way to communicate [threats and appropriate behaviors] as they come and go, and we need a national standard" and that the US needs to "develop a color coded system like we did after 9-11 to indicate safety levels and restrictions while we get to a vaccine" [15]. Whilst a vaccine-based solution that can lessen the spread of the disease is vital, this will take time, and future waves need to be managed effectively over potentially long time scales. Building a warning system to address these needs requires bringing together expertise from all areas of disaster management, beyond the fields of epidemiologists and mathematicians, so to establish and manage effective EWS for the government bodies that will use it to trigger protocols. In our interconnected world, pandemic EWS, moreover, will be needed beyond the current COVID-19 crisis.

Clearly pandemics unfold differently as disasters to eruptions, earthquakes, tsunamis and floods. They have different monitoring (or 'sentinel') systems in place that deal with complex sociomedical data and emerging contexts. Furthermore, the behaviours expected or required of individuals in times of crisis will be different. But, these crises involve many of the same governmental organisations, industries, and deal with the same publics as the now well established EWS rely on and target. EWS hinge on a set of questions that are relevant to any disaster, such as:

- How can a multi-scaled early warning system work, maintaining communication, accountability and transparency across state and scientific agencies?
- What combinations of text and iconographies work across traditional and social media (Facebook, Twitter, WhatsApp etc.) to indicate risk levels, and required or advised actions?
- What elements can be usefully standardised for international cooperation and cross-border guidance, and what elements are usefully made contingent on local and regional narrative tropes to more effectively communicate risk and guidance?

As more political administrations look to EWS to help mitigate future waves of COVID-19, evidence-based considerations from the study of EWS and environmental hazards can lay the ground for discussion. The key findings to be carried forward are as follows:

1. Translation and multi-way communication is required to ensure that all involved in designing and assigning alerts understand what information is credible and relevant [16]. Common communication tools adopted to achieve this include cooperation plans, protocols and procedures. But, these activities are themselves dependent upon everyday dialogues between stakeholders via differing formats (social networking, internet, phone), and the establishment of joint information centres, meetings, and workshops.

2. Whilst alert level systems are used globally as a visual and text-based shorthand system to convey concise and clear information to a wide range of people, scientific uncertainties can make alert levels complicated to use. The decision to change an alert level is challenging as often scientists encounter difficulties in interpreting scientific data to establish what a hazard is doing, and that the decision to move between alert levels is based upon a complex negotiation of perceived political, economic, and environmental risks rather than the scientific data [17]. Warning systems are complex and nonlinear and a consideration of different understandings of uncertainty and risk is required for decision-making processes in assigning alert / warning [18].

3. The standardisation of alert levels and early warning systems is vital to convey information to a wide range of stakeholders. However, the process of standardisation is shaped by social, political, and economic factors rather than in response to scientific needs specific to a hazard; and standardisation is difficult to implement due to the diversity and uncertain nature of hazards at different temporal and spatial scales [19]. EWS need to be scalable and sufficiently flexible for use by local stakeholders via standardised communication products designed to accommodate local contingency, while also adhering to national / international policy.

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Carina J. Fearnley*
Department of Science and Technology Studies
University College London, Gower Street
London, WC1E 6BT, United Kingdom
E-mail address: c.fearnley@ucl.ac.uk

Deborah Dixon
School of Geographical & Earth Sciences
University of Glasgow
Glasgow, G12 8QQ, United Kingdom
E-mail address: Deborah.Dixon@glasgow.ac.uk

*Corresponding author